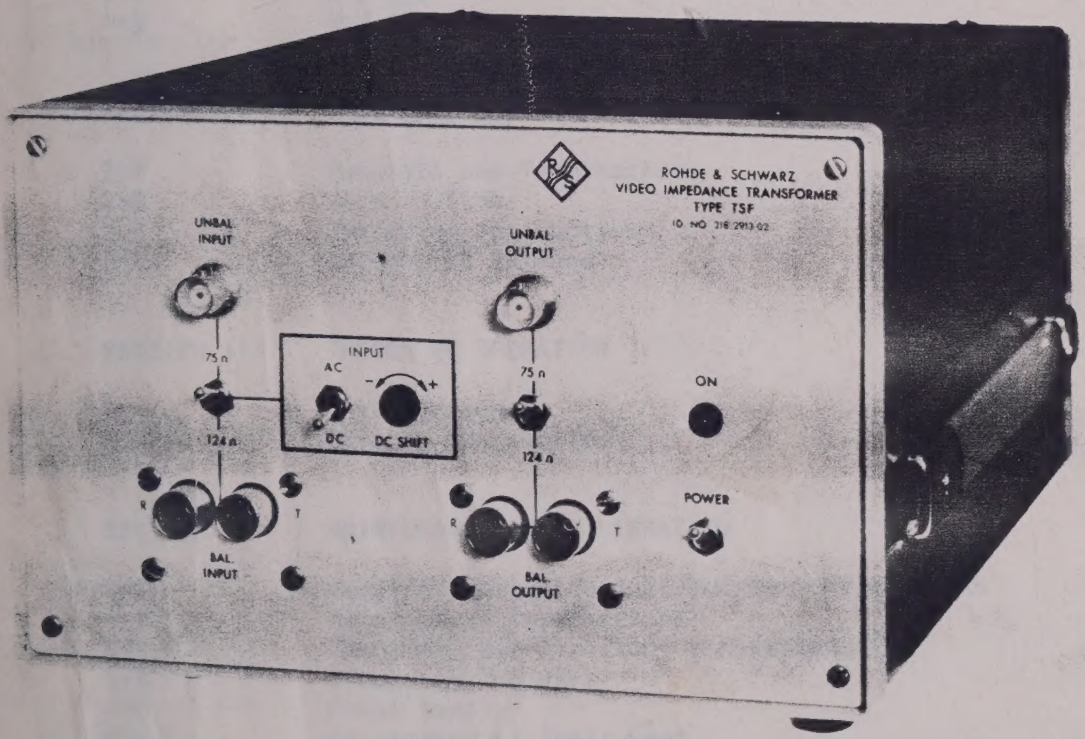
TYPE TSF

OPERATING AND SERVICE MANUAL



VIDEO IMPEDANCE CONVERTER

MP MASTER
MA22464

ROHDE & SCHWARZ SALES CO.
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SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION & APPLICATIONS

Type TSF Video Impedance Converter is an active-circuit instrument which interfaces all 75 Ω video unbalanced circuits, coaxial cables, amplifiers, equalizers, and other transmission equipment with 124 Ω balanced video circuits, telephone and other transmission lines, and test equipment. This impedance transformation is made without introducing any discernable signal degradation nor insertion loss. Input signals can be AC or DC coupled with ± 1 VDC offset control.

SWITCHABLE OPERATIONAL MODES

Input	Output
75 Ω Unbalanced	124 Ω Balanced
124 Ω Balanced	75 Ω Unbalanced
124 Ω Balanced	124 Ω Balanced
75 Ω Unbalanced	75 Ω Unbalanced

In addition to providing impedance conversion, Type TSF can be used at the same input/output impedance to provide > 40 dB line isolation, owing to its separate input/output grounds.

Another important application is use as an interface between 124 Ω balanced telephone equipment and present standard test instruments. TSF eliminates the need for telephone operating companies to rely solely on using special-purpose 124 Ω balanced test instruments. The unit can be used at TV studios, transmitters, mobile TV vans, on closed circuit TV transmission systems, links between TV station and telephone equipment, and in development laboratories and production testing facilities.

1-2 POWER LINE REQUIREMENTS

CAUTION

The instrument operates from AC power sources of 115 or 220-volts, 50 to 400 Hz. The instrument has been shipped connected for 115 VAC line power operation. For operation from 220 VAC service, change the position of the line voltage slide switch and change the fuse to 1/8 amp. Both the switch and the fuse holder are located on the rear of the instrument.

To protect operating personnel, the instrument is equipped with a three-conductor line power cable, which when plugged into an appropriate receptacle, grounds the case of the instrument. The round pin on the power cable's three-prong connector is the ground connection. To preserve this protection feature when the instrument is operated from a two-contact outlet, use a 3 to 2-prong adapter and connect the green pigtail on the adapter to an external ground.

1-3 DAMAGE IN TRANSIT

Before shipment, this instrument was inspected and was found to be free of any electrical or mechanical defects. It has been carefully packed by us at time of shipment. The instrument should be thoroughly inspected when it is received. If any damage is evident, a claim should be filed by you with the carrier. Be certain to retain the shipping case for inspection by the carrier's agent. A full report of the damage or malfunction should be immediately sent to us or your local R&S representative.

1-4 STORAGE

The set should not be stored for extended periods of time under extreme environmental conditions. The components can withstand temperatures between 20°C and +70°C without damage. Temporary condensation is harmless when moving the set to heated surroundings.

1-5 SPECIFICATIONS

The specifications for the Type TSF are shown below:

Gain:	0 dB ± 0.1 dB
Frequency Response:	± 0.05 dB to 5 MHz ± 0.1 dB to 10 MHz
Input/Output Voltage:	1 V_{pp} unbalanced into 75 Ω 1 V_{pp} balanced into 124 Ω
DC Balance Offset:	± 1 VDC
Maximum Common Mode Voltage:	10 V_{pp}
Common Mode Suppression:	> 60 dB, 60 Hz; typical
Impedance between Input/Output Grounds:	100 k Ω shunted by 10 nF
Typical Return Loss:	
All Inputs:	40 dB to 10 MHz
124 Ω Output:	40 dB to 10 MHz
75 Ω Output:	40 dB to 5 MHz 34 dB to 10 MHz
Symmetry:	> 50 dB
Sag & Tilt (60 Hz):	< 0.5 %
Differential Phase:	0.1° at 1 V_{pp}; 10-90 % APL
Differential Gain:	0.5% at 1 V_{pp}; 10-90 % APL
Input/Output Connectors:	75 Ω BNC female; Western Electric Type 465; 124 Ω Balanced
Dimensions:	8" W x 6" H x 11" D; (19 in. rack model available)
Weight:	6 lbs.
Line Power:	115/230 V_{rms} ± 10%, 50-400 Hz

SECTION II
OPERATING INSTRUCTIONS

2-1 CONTROLS AND TERMINALS

Controls and terminals for operation are shown in Fig. 2 - 1.

2-2 WARM-UP TIME

Before using the instrument, it should be warmed-up for a period of at least 10 minutes. This will insure that the DC balance control can be set accurately.

2-3 OPERATING INSTRUCTIONS

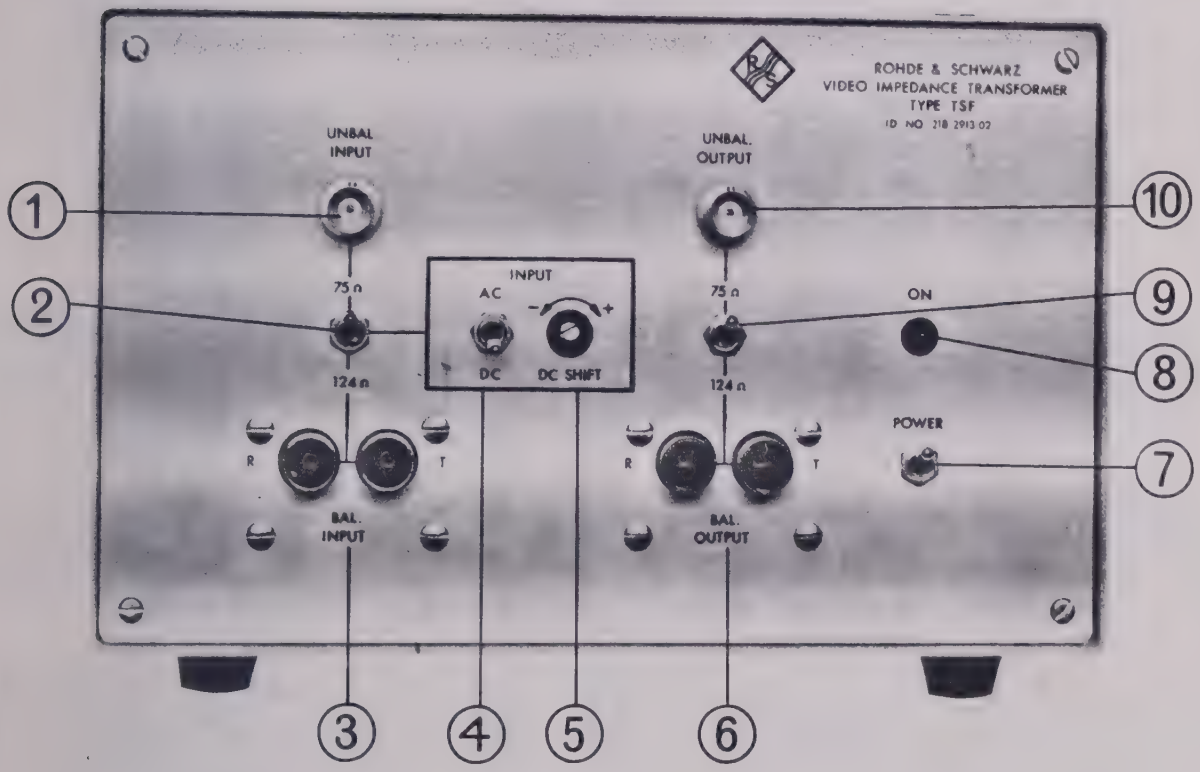
Instructions for operation of the Type TSF are illustrated in Fig. 2-2.

2-4 SETTING DC BALANCE

To insure lowest distortion and optimum operating point, it is necessary to properly adjust the DC SHIFT (R 5) control with either AC or DC coupling. When AC-coupled, connect a DC voltmeter or oscilloscope between the center conductors (R&T) of BAL. OUTPUT (J 3), and with no input signal present, using the DC SHIFT potentiometer (R 5), adjust the DC output level to < 50 mV.

When the instrument is DC-coupled, apply a standard 1 V composite video signal with 50% APL to the input. Terminate the "R" connector of the BAL. OUTPUT (J 3) with a 62 Ω load. Set output impedance switch (S 3) to 124 Ω. Connect an oscilloscope (unterminated) to the "T" connector of the BAL. OUTPUT (J 3). Adjust the DC SHIFT potentiometer (R 5) so the blanking level is < 50 mVDC. Interchange the termination and oscilloscope connections (R&T). The blanking level should remain at < 50 mVDC.

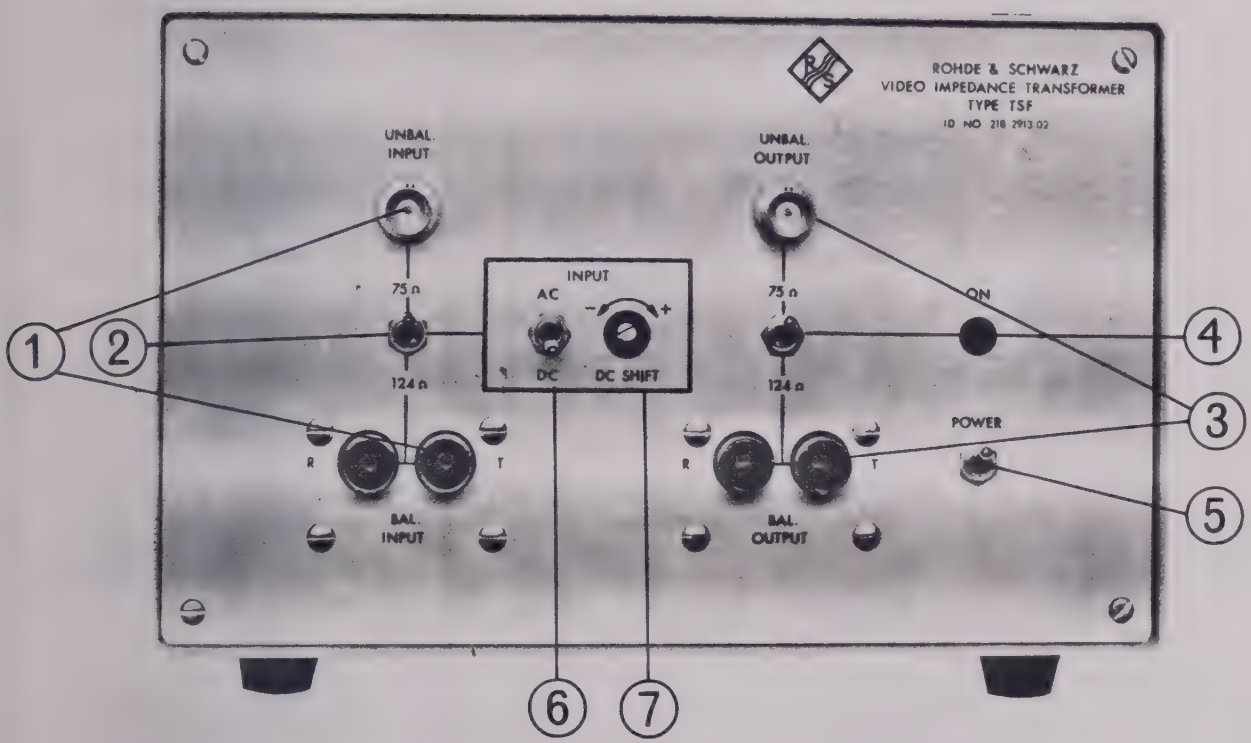
OPERATING CONTROLS



1. 75 Ω Unbalanced input; BNC socket
2. Input switch, selects 75 Ω or 124 Ω as input.
3. 124 Ω Balanced input; telephone-type socket
4. AC/DC Input coupling selector switch
5. DC Output balance control
6. 124 Ω Balanced output; telephone-type socket
7. Line power switch
8. Line power pilot lamp
9. Output switch? selects 75 Ω or 124 Ω as output
10. 75 Ω Unbalanced output; BNC socket

FIG. 2-1

OPERATING INSTRUCTIONS



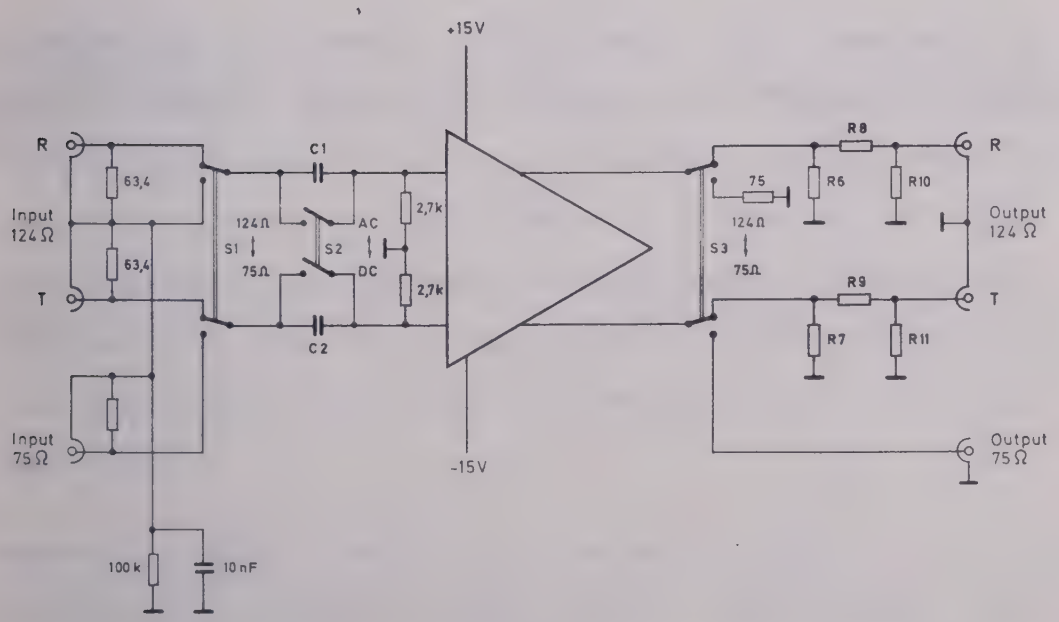
1. Connect input signal to appropriate INPUT
2. Set for appropriate input
3. Connect to appropriate OUTPUT
4. Set for appropriate output
5. Switch POWER on and allow a 10 minute warm-up period
6. Set for AC or DC INPUT coupling
7. Adjust DC SHIFT as described in Section 2-4

FIG. 2-2

SECTION III
THEORY OF OPERATION

3-1 INTRODUCTION

The TSF functionally consists of a balanced differential amplifier with push-pull outputs, capable of handling high common mode voltages at the input. Separate switching facilities permit all combinations of 75 Ω unbalanced/124 Ω balanced inputs/outputs. Optimum performance is obtained when the DC differential voltage at the balanced outputs is adjusted to zero using the front panel DC offset control. Electronically stabilized power supplies insure high performance under varying line voltage conditions. Over 24 circuit-stages are utilized to provide and insure high performance, high stability and infrequent recalibration and maintenance. The Block Diagram for Type TSF is shown below:



3-2 CIRCUIT DESCRIPTION

DIFFERENTIAL AMPLIFIER

The inputs J 1 and J 2 are connected to the differential input of the amplifier (pins 1 and 2) via the input selector switch S 1. The coupling capacitors C 1 and C 2 are by-passed by AC/DC selector switch S 2 for DC inputs.

The differential amplifier Q 111/Q 112 is provided with constant current by the current source Q 105/Q 106. This current can be asymmetrically divided for the two amplifier paths by means of R 5 and Q 115/Q 116, so as to compensate for a DC-input voltage unbalance. The common-base stages Q 113 and Q 114 insure an extremely high-impedance current input to the two differential-amplifier transistors Q 111 and Q 112. The gain is determined by the emitter resistor R 125 and the operating resistors R 145 and R 155 of the common-base stages Q 120 and Q 125. The frequency response is determined by means of R 124 and C 104/C 105, which have been factory selected.

To insure that the differential amplifier has as high a common-mode rejection as possible, the collector voltages of the differential-amplifier transistors Q 111 and Q 112 are kept at a constant level and, free of hum voltage by the common-base stages Q 109 and Q 110. The emitter follower Q 101 brings the hum voltage from the outer conductor of the connected signal via R 111 to the bases of the transistors Q 109 and Q 110. R 111 only effects the DC offset voltage since constant current from Q 108 flows through it.

Common-base stages Q 109 and Q 110 provide emitter voltages to the common-base stages Q 120 and Q 125. R 120/R 121 have no influence upon the gain of the circuit. The operating point of Q 120 & Q 125 is determined by the base

divider R 140/R 141, which is temperature compensated by Q 124. Resistors R 145 and R 155 are compensated by the L-R networks L 100/R 146 and L 101/R 156 to correct for thermal "sag and tilt" evidenced by the rounding of a line-rate squarewave. Using R 148 and R 158, the gain of both outputs can be adjusted independently to the correct values. C 111 or C 112 is used for compensation of frequency response asymmetry in the two output channels.

The output stages of both amplifier channels are impedance converters. Each has the same degree of negative feedback. Both output stages Q 122/ Q 123 and Q 127/ Q 128 receive an output source impedance of 75 Ω by means of R 167/R 168 and R 165/R 166 respectively. Two transforming 6-dB attenuator pads in a Π-circuit are connected via output selector switch S 3 at the balanced output and these insure the correct output level and source impedance.

In order to reduce the differential phase error in unbalanced operation, both the inputs and the outputs are provided with separate compensation circuits. In the output stages these consist of collector-base diodes of transistors Q 121 and Q 126 and/or the varactor diodes CR 110/CR 111. By means of R 143 and R 153 the output asymmetry of the differential phase can be minimized. The inputs are each compensated by a varactor diode CR 101 and CR 104. Asymmetry can be removed by an additional diode and a fixed capacitor in either input (CR 102/C 103 or CR 103/C 102). The anode voltages of the varactor diodes at the input are partly controlled by the common-mode hum voltage via the emitter follower Q 102 and the voltage-offset element CR 100/Q 103, so that the differential phase is independent of the common-mode voltage.

POWER SUPPLY

The power supply for Type TSF basically consists of a power transformer, bridge rectifier, and integrated circuit regulators.

Power transformer (T 1) provides approximately 40 V_{rms} to a bridge rectifier (CR 201). This raw voltage is filtered by C 201, C 202, and R 203. The subsequent DC voltage is then connected to two Types LM 3407-15 IC regulators (U 201) and U 202) whose outputs are matched to be within 100 mV. These provide the ± 15 VDC stabilized voltage for operation of the TSF's circuitry. A floating DC voltage supply ground is used to minimize hum and noise in the video output signals. An LED indicator (D 201) is used to indicate a "power-on" status.

SECTION IV
MAINTENANCE & CALIBRATION

4-1 REQUIRED MEASURING INSTRUMENTS AND ACCESSORIES

The following equipment can be substituted by equivalent instrumentation providing performance equal or better than those of recommended types are maintained.

Video Test Signal Generator, R&S Type SPF

Video Standard Level Generator, R&S Type SNF

Videoskop, R&S Type SWOF III

Video Noise Meter, R&S Type UPSF

Precision Oscilloscope, e.g. Tektronix Type 545B

Differential Phase/Gain Meter, R&S Type PVF

Video Distribution Amplifier, R&S Type AVF

Two Isolating Transformers

Low-voltage Power Transformer with output 4 to 6.3 VAC

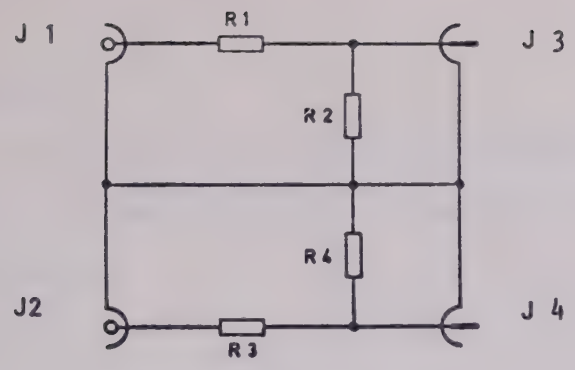
Two 62-Ω BNC terminations; < 0.1%, tolerance

Two identical 60-Ω connecting cables; 1 m ± 1 cm long

Connectors: 124-Ω plug (for both cables together) and BNC plug in each case

High Impedance Digital Voltmeter

Two Twin Matching Pads; 2x62 Ω / 2x75 Ω as shown:



R 1 & R 3 = 31.22 Ω ± 0.1 %

R 2 & R 4 = 148.92 Ω ± 0.1 %

J 1 & J 2 = BNC socket, 75 Ω

J 3 & J 4 = Balanced Plug, 124 Ω

Insure adequate isolation of both halves when setting up.

Voltage attenuation:

Transforming a 75-Ω source down to 62 Ω: 0.584 = -4.68 dB

Transforming a 62-Ω source up to 75 Ω: 0.706 = -3.02 dB

With 2 matching pads (back to back): 0.412 = -7.70 dB

4-2 MAINTENANCE INSTRUCTIONS

No periodic maintenance is necessary.

4-3 CHECKING THE SPECIFICATIONS AND RECALIBRATION

The specifications listed in paragraph 1-4 can be checked using equipment recommended in paragraph 4-1, or using comparable-quality instruments. The test procedures in paragraph 4-6 can be used.

4-4 ELECTRICAL REPAIRS

Whenever repairing or testing, Type TSF should preferrably be operated from the power line via a regulating buffer transformer in order to reduce the risk of accident.

Faulty components can normally be replaced by those of the same type without complete realignment being necessary. Because of the balanced circuits; however, replacement of pairs of components will be required in some cases. To simplify trouble-shooting and isolation of defective components, DC operating voltages of all active components are indicated on the schematic. The alignment components of the Type TSF are mounted on the stand-offs. This facilitates trimming of components whenever necessary.

Whenever realignment of the unit is required, it is strongly suggested that all parameters be checked. The set is shipped from the factory with all parameters optimally adjusted. Altering one set of adjustments can influence more than one parameter. In case of doubt return the unit to us for complete restoration to original specifications.

4-5 POWER SUPPLY

The power supply should be checked with nominal line voltage of 115 V (60 Hz) or 230 V (50 Hz). Using the DC DVM, measure voltage from pin 5 (+15 V) to pin 8 (0 V). The voltage should be + 15 VDC ± 0.5 V. Then measure from pin 11 (-15V) to pin 8. This voltage should be - 15 VDC ± 0.5 V. Voltage regulators U 201, U 202 should be tested for matched outputs within ±100 mVDC.

If the voltage reading is not within these limits, attempts should be made to isolate the fault either to the power supply or amplifier.

4-6 ADJUSTMENT OF INSTRUMENT

Fault location in the amplifier can easily be accomplished by tracing the video signal through various stages in sequence. Adjustment of the amplifier, if not stated otherwise, is made in the following mode:

S 1	124 Ω
S 2	AC
S 3	124 Ω

A) DC-Voltage Adjustment

R 5: Adjust DC-voltage difference at the outputs T and R to < 50 mV (without terminations)

R 107: Adjust the absolute value at both outputs T and R to < 50 mV.

B) Preliminary Frequency Response Check

Initial adjustment in factory: Replace R 124 with 56 Ω resistor (N.B: If another value is found to be permissible, then this can also be inserted).

Using Type SWOF III Videoskop, measurement of frequency response should be made between each 62 Ω input section and each 62 Ω output section of the 124 Ω connectors, with matching pads of 75 Ω/ 62 Ω connected in between the TSF and the test instrument. Coarse adjustment is made with C 105. Maximum frequency response difference should be < 0.5 dB at 10 MHz and < 1.0 dB at 20 MHz; otherwise a fault exists.

C) Differential Phase

Because of the varying input and output connections of the amplifier, the differential phase is adjusted separately at each input and output. The set-up is shown in Fig. 4-2. Connect to the TSF input a pure line frequency sawtooth (50% APL) test signal with approximate amplitude of 2 V_{pp} across 62 Ω. This simplifies the adjustment since the modulation range of a standard CVS(Composite Video signal) with 10-90% APL is covered. The inherent error of the signal should be < 0.1^{o}.

1. Measurement of the circuit, uncompensated.

   The results obtained could be interpreted as follows:

Negative Value

Positive Value

Enter the values in the following table with correct sign.

	Output T	Output R
Input T	M1 =	M2 =
Input R	M3 =	M4 =

$(M1 - M2) \div 2 < 0.1^{o}$

$(M4 - M3) \div 2 < 0.1^{o}$

$(M1 + M3) \div 2 < 0.1^{o}$ $(M2 + M4) \div 2 < 0.1^{o}$

The circuit is balanced if M1 = M4; and M3 = M2. If large differences in their values exist, the unit should be returned to the factory.

2. Compensation of Inputs

By switching the varactor diodes CR 102, CR 103, of the corresponding equivalent capacitors C 102, C103, the inputs are compensated so the values of M1 & M3, and M2 & M4 become equal and opposite in polarity, i.e. M2 = -M4, M3 = -M1. Thus we obtain M1 $\underset{\sim}{=}$ M4 and M2 $\underset{\sim}{=}$ M3. Complete equality of these values is unnecessary since they are governed by the ouput compensation.

3. Compensation of the Outputs

Preset: R 143, R 153 to 0 Ω.

Output T: By switching Q 121 or CR 110 or CR 110 plus Q 121, the differential phase is optionally adjusted for both inputs. Slight overcompensation can be corrected using R 143.

Ouput R: Adjustment can be made by switching Q 126 or CR 111, or CR 111 and Q 126. Final adjustment is made with R 153.

4. Checking at normal modulation

Final check is made with 1 V_{pp} CVS (Composite Video Signal). With an APL (Average Picture Level) of 10 to 90%, differential phase must be < 0.1° in all modes. The same applies for DC coupling.

D) Differential Amplitude

The differential amplitude must be < 0.5%. Measurement should be made with a CVS of 1 V_{pp} and an APL of 10 to 90% according to setup as in Fig. 4-2.

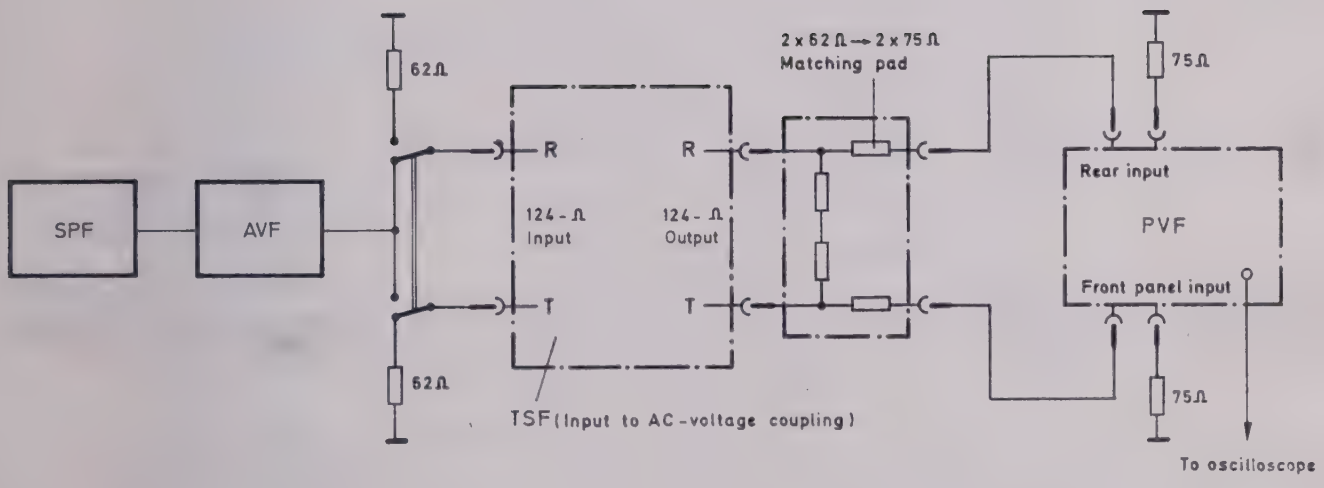
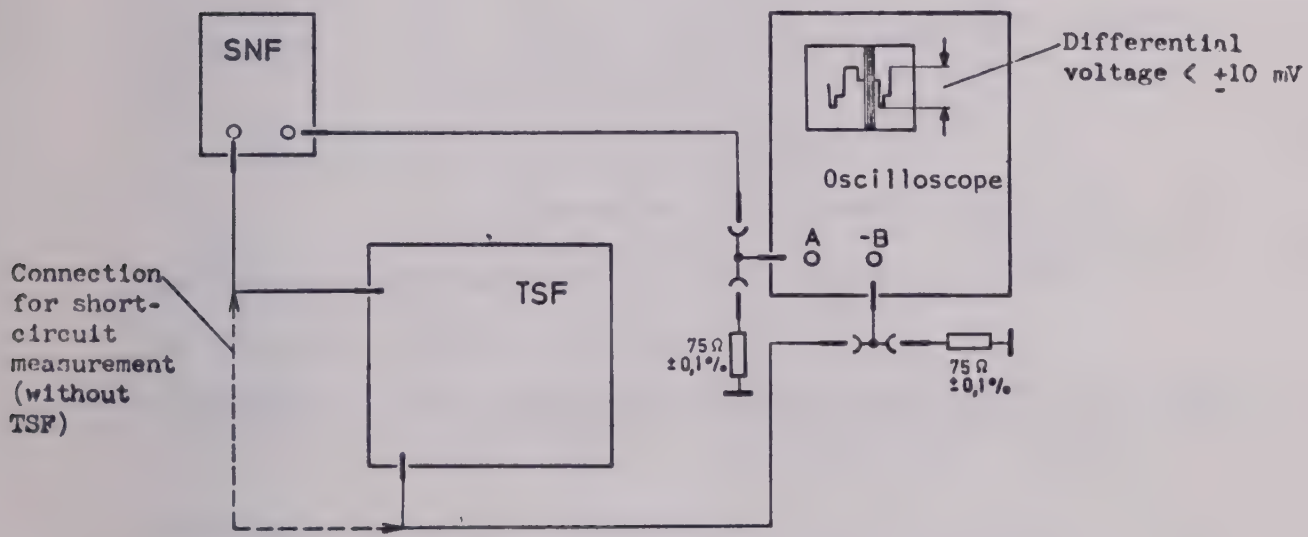


Figure 4-2
Test setup for adjusting the differential phase

E) Fundamental Gain

With a 100 kΩ potentiometer connected in place of R 148, the gain between the 75 Ω input and 75 Ω output is adjusted to 0 dB ± < 0.1 dB.

Although in principle, an accurate comparison is sufficient for this (with and without the TSF, the adjustment can be carried out most accurately with the following setup:



F) Internal S/N Ratio

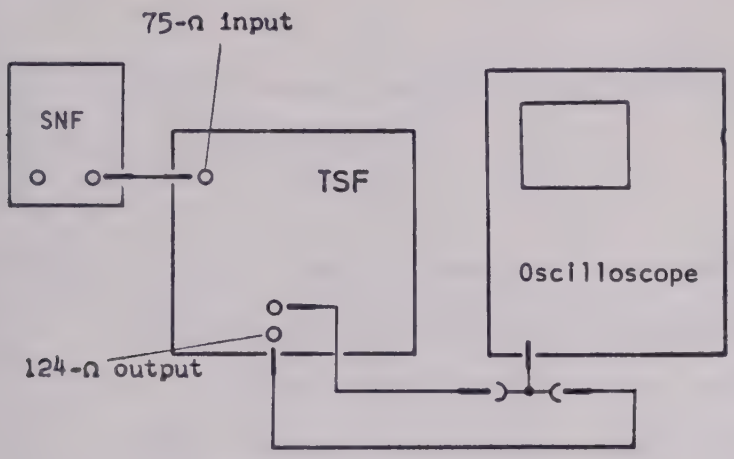
The internal S/N ratio is measured without any input signal and connecting the R&S Type UPSF Video Noise Meter to the outputs.

It must be:

at the 75 Ω ouput:	≥ 66 dB	peak-value measurement
at the 124 Ω R output:	≥ 72 dB	with video filter on
at the 124 Ω T output:	≥ 72 dB	and low pass filter on.

G) Output Symmetry

With a fixed value resistor connected at R 158 (the value determined for R 148 is taken as a guide), the symmetry of the 124 Ω output is optimally adjusted with the following setup:



The differential voltage on the oscillator must be < 1 mV for low frequencies (15-kHz squarewave).

Then repeat the DC-voltage adjustment with R 5 and R 107.

H) Return loss

The return loss of the inputs and outputs is adjusted to a fixed value. Corrections can be made with the following components:

Inputs: By small capacitors parallel to the input or by inserting ferrite beads of 42 to 90 nH in series with the input terminating resistors.

Outputs: 124-Ω output: C 3, C 4

75-Ω output: C 5, R 13

The nominal return loss should be ≥ 40 dB up to 10 MHz, corresponding to an uncompensated series Ω of 20 nH or a parallel C of 5 pF.

1) Frequency Response

The frequency response is measured from each 75 Ω and 124 Ω input to each 75 Ω and 124 Ω ouput with the 124 Ω 2 x 75 Ω matching pads connected.

During adjustment, the frequency range to about 20 MHz is also to be taken into consideration.

C 111, C 112: Differing frequency response at the outputs T and R (feeding in at the 75 Ω input) is corrected by means of C 111 (for output T) or C 112 (for output R), the higher frequency response being reduced. Differing frequency response at the 75 Ω output (feeding in at input T or inout R) is corrected by altering the capacitor C 102 and C 103 (approx. value, 10 pF). If C 102 and C 103 are not present, a smaller value at the input is sufficient, i.e. at the input which processes the rising frequency response at the output.

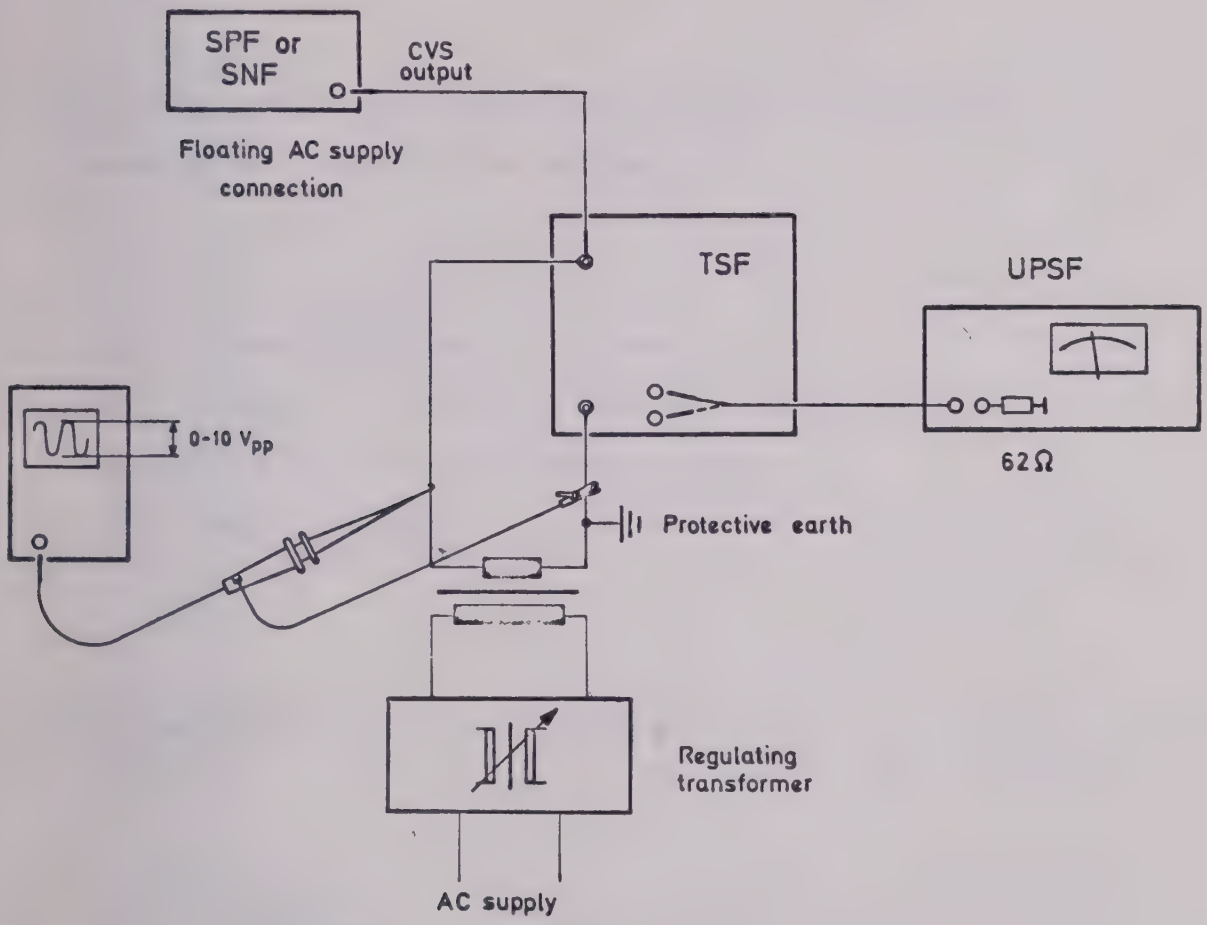
R 124, C 104, C 105: The frequency response adjustment is made with C 105. If the range is inadequate, C 104 is replaced by a capacitor with another value. An excessive rise in the frequency response above 10 MHz is corrected by means of R 124. Response Tolerances:

up to 5 MHz	±0.05 dB
5 - 10 MHz	± 0.1 dB
10 - 20 MHz	< ± 0.5 dB (approx.value)

Finally: Check the return loss of the inputs.

J) Common-mode Rejection

Test Set-up:



Connect 10 V_{pp} 60 Hz from a transformer to the outer conductors of both the 75 Ω input and output. A line-frequency CVS is also applied to the 75 Ω input. Measure at the 124 Ω T output or 124 Ω R output with the R&S Video Noise Meter, Type UPSF, with the blanking turned off and the 1-kHz lowpass filter switched on. For common-mode hum voltages up to 10 V_{pp} the noise voltage must be < 5 mV_{pp}.

SECTION V
PARTS DOCUMENTATION

This section contains the following documentation which will assist in component parts identification and servicing:

1. Table of Replaceable Parts
2. Internal Photographs of Instrument
3. Printed Circuit Board Parts Layout
4. Silk Screen Parts Identification Layout
5. Electrical Schematic

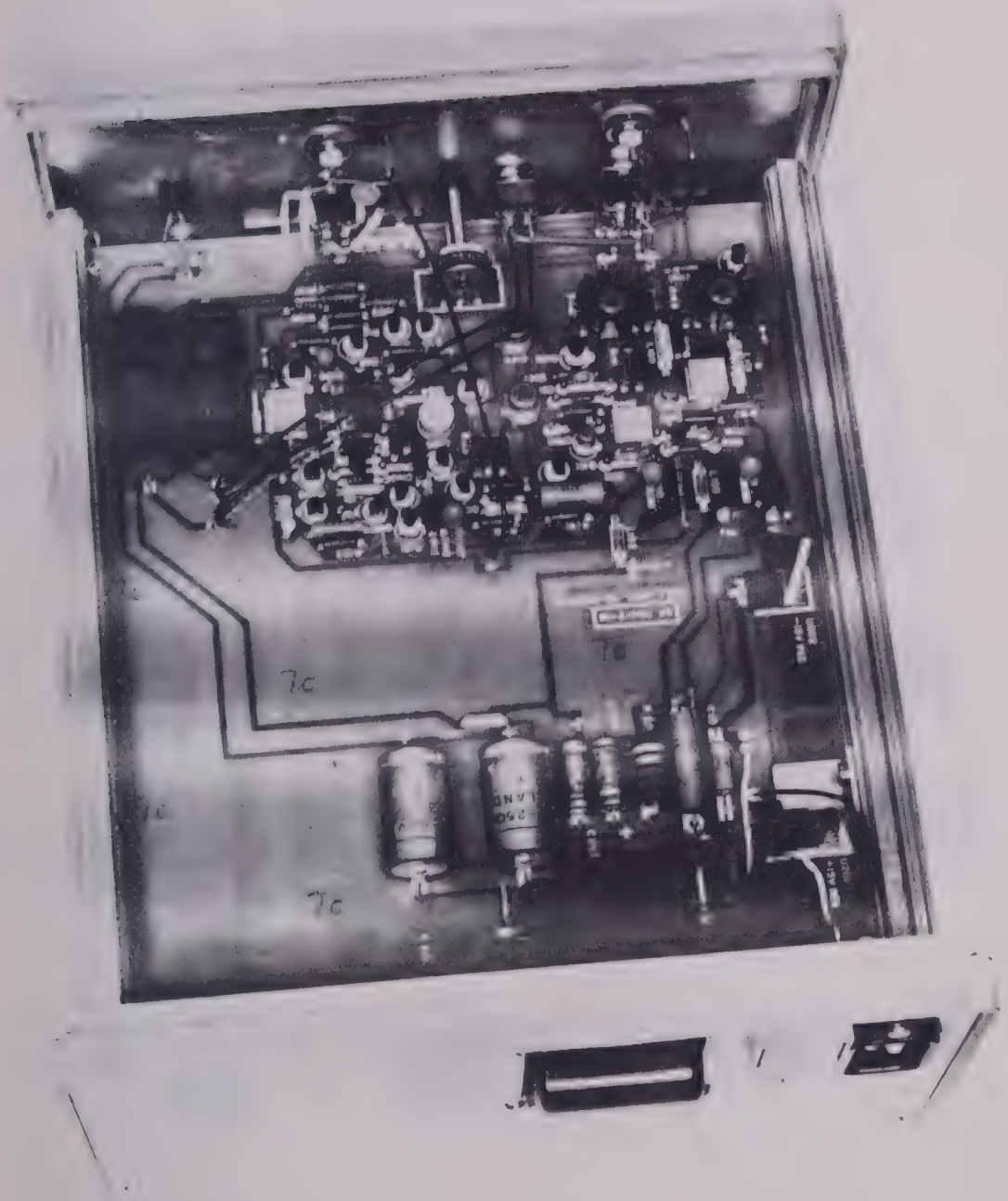
TABLE OF REPLACEABLE PARTS

Ref. Designator	Value	Rating/Tolerance	Type	Stock No.
CAPACITORS				
C 1	470 uF	6 V	Electrolytic, Al	07102420 A
C 2	470 uF	6 V	Electrolytic, Al	07102420 A
C 3	3.9 pF	±10 %	Ceramic, Tubular	07025110 A
C 4	4.7 pF	500 V	Ceramic, Disc	07100060 A
C 5	10 pF		Ceramic Tubular	07025510 A
C 6	2.2 nF	200 V, 5%	Ceramic, Tubular	07023660 A
C 7	2.2 nF	200 V, 5%	Ceramic Tubular	07023660 A
C 8	*		Factory Selected	-
C 9	*		Factory Selected	-
C 10	47 nF	400 V, 20%	Mica Molded	07081300 A
C 11-99	-		Not used	-
C 100	10 nF	200 V, 5%	Paper Foil	07023650 A
C 101	1 nF	63 V	Polystyrene Foil	07102190 A
C 102	*		Factory Selected	-
C 103	*		Factory Selected	-
C 104	*		Factory Selected	-
C 105	7-25 pF	300 V	Ceramic, VAR.	07100100 A
C 106	10 uF	35 V	Electrolytic, Ta	07100530 A
C 107	10 uF	35 V	Electrolytic, Ta	07100530 A
C 108	-		Not used	-
C 109	-		Not used	-
C 110	*		Factory Selected	-
C 111	*		Factory Selected	-
C 112	*		Factory Selected	-
C 113-119	-		Not used	-
C 120	47 uF	20 V	Electrolytic, Ta	07101830 A
C 121	47 uF	20 V	Electrolytic, Ta	07101830 A
C 122-200	-		Not used	-
C 201	330 uF	63 V; -10,+50%	Electrolytic, Al	07102520 A
C 202	330 uF	63 V; -10,+50%	Electrolytic, Al	07102520 A
C 203	100 uF	25 V	Electrolytic, Al	07102350 A
C 204	100 uF	25 V	Electrolytic, Al	07102350 A
C 205-300	-		Not used	-
C 301	1.5 nF	3 kV; -20, +80%	Ceramic, Disc	07025430 A
C 302	1.5 nF	3 kV; -20, +80%	Ceramic, Disc	07025430 A
DIODES				
CR 100	1 N 3508	3.9 V, 400 mW	Zener	05100440 A
CR 101	MV 2203		Varactor	05100550 A
CR 102	*		Factory Selected	-
CR 103	*		Factory Selected	-
CR 104	MV 2203		Varactor	05100550 A
CR 105	1 N 270		Diode	05100520 A
CR 106-109	-		Not used	-
CR 110	MV 2203		Varactor	05100520 A
CR 111	MV 2203		Varactor	05100520 A
CR 112-200	-		Not used	-

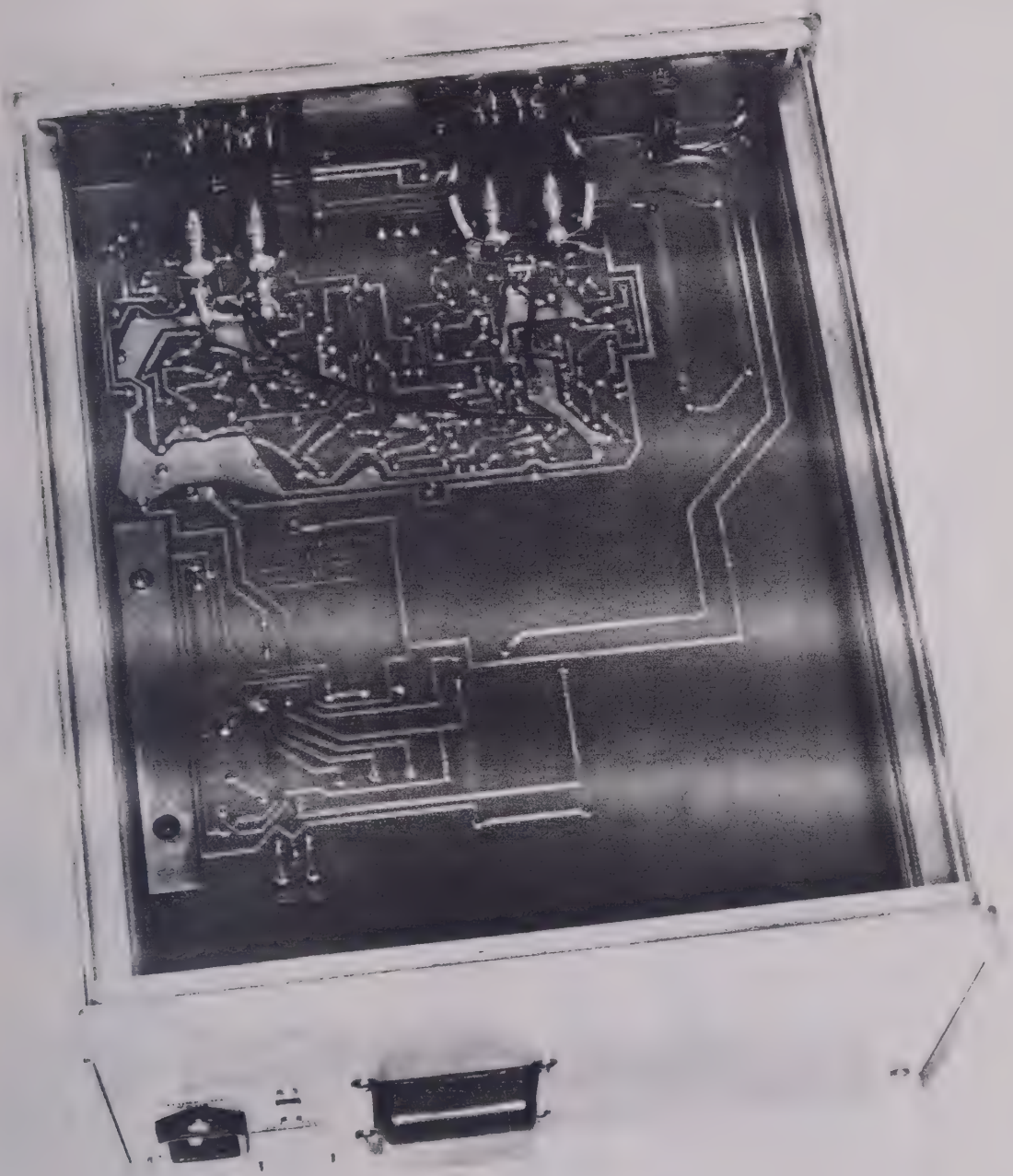
Ref. Designator	Value	Rating/Tolerance	Type	Stock No.
DIODES				
CR 201	WO 4 M		Bridge Rectifier	05100060 A
LAMP				
D 201			LED Panel Ind.	16100000 A
FUSE				
F 1		½ Amp.	Fuse, 3 AG	19034020 A
CONNECTORS				
J 1			Jack, Coaxial, 124 ohm Bal.	31100930 A
J 2	UG-1094/u		Jack, BNC	31033790 A
J 3			Jack, Coaxial, 124 ohm Bal.	31100930 A
J 4	UG-1094/u		Jack, BNC	31033790 A
INDUCTORS				
L 100	0.47 uH		Coil, Molded	03100020 A
L 101	0.47 uH		Coil, Molded	03100020 A
L 102	8.2 uH		Coil, Molded	03100360 A
L 103	8.2 uH		Coil, Molded	03100360 A
TRANSISTORS				
Q 101	MPS 6523			10100750 A
Q 102	MPS 6521			10094850 A
Q 103	MPS 6520			10100740 A
Q 104	-		Not used	-
Q 105	MPS 6520			10100740 A
Q 106	MPS 6520			10100740 A
Q 107	-		Not used	
Q 108	MPS 6519			10100090 A
Q 109	MPS 6520			10100740 A
Q 110	MPS 6520			10100740 A
Q 111	MPS 6521			10094850 A
Q 112	MPS 6521			10094850 A
Q 113-116	MPS 6520			10100740 A
Q 117-119	-		Not used	-
Q 120	2 N 2905			10100760 A
Q 121	BCY 59 C			10100730 A
Q 122	MPS 6520			20200740 A
Q 123	2 N 2905			10100760 A
Q 124	MPS 6519			10100090 A
Q 125	2 N 2905			10100760 A
Q 126	BCY 59 C			10100730 A
Q 127	MPS 6520			10100740 A
Q 128	2 N 2905			10100760 A

Ref. Designator	Value	Rating/tolerance	Type	Stock No.
RESISTORS				
(Unless otherwise noted: All values in ohms; ratings 0.5 watts, tolerance ±1%; metal film type)				
R 1	63.4			12121770 A
R 2	63.4			12121770 A
R 3	76.8			12121850 A
R 4	-		Not used	-
R 5	50	1w; 20%	Wirewound, Var.	09101141 A
R 6	562			12122720 A
R 7	562			12122720 A
R 8	43.2	¼w; ± 1%		12128070 A
R 9	43.2	¼w; ± 1%		12128070 A
R 10	143	¼w; ± 1%		12128080 A
R 11	143	¼w; ± 1%		12128080 A
R 12	75			12121840 A
R 13-14	-		Not used	-
R 15-17	37.4			12121550 A
R 18-99	-		Not used	-
R 100	2740			12123420 A
R 101	2740			12123420 A
R 102	100 k			12125000 A
R 103	-		Not used	-
R 104	221			12122330 A
R 105	221			12122330 A
R 106	1210			12123080 A
R 107	500	½w; ± 10%	Composition, Var.	09100010 A
R 108	1000			12123000 A
R 109	221			12122330 A
R 110	46.4			12121640 A
R 111	2150			12123320 A
R 112-115	-		Not used	-
R 116	562			12122720 A
R 117	1210			12123080 A
R 118	12.1 k			12124080 A
R 119	-		Not used	-
R 120	100			12122000 A
R 121	100			12122000 A
R 122	221			12122330 A
R 123	221			12122330 A
R 124	*		Factory Selected	-
R 125	255			12122390 A
R 126	3920			12123570 A
R 127	221			12122330 A
R 128	221			12122330 A
R 129	825			12122880 A
R 130	3920			12123570 A
R 131-134	-		Not used	-
R 135-137	46.4			12121640 A

Ref. Designator	Value	Rating/Tolerance	Type	Stock No.
R 138-139	-		Not used	-
R 140	562			12122720 A
R 141	1000			12123000 A
R 142	-		Not used	-
R 143	1000	½w; ± 10%	Metal Film, Var.	09100220 A
R 144	-		Not used	-
R 145	562			12122720 A
R 146	5.6	½w; ± 5%	Composition	12011090 A
R 147	464			12122640 A
R 148	*		Factory Selected	-
R 149	-		Not used	-
R 150	392			12122570 A
R 151	464			12122640 A
R 152	-		Not used	-
R 153	1000	½w; ±10%	Metal Film, Var.	09100220 A
R 154	-		Not used	-
R 155	562			12122720 A
R 156	5.6			12123720 A
R 157	464			12122640 A
R 158	*		Factory Selected	-
R 159	-		Not used	-
R 160	392			12122570 A
R 161	464			12122640 A
R 162-164	-		Not used	-
R 165	75	¼w; 0.25%	Metal Film	12128060 A
R 166	8250			12123880 A
R 167	75	¼w; 0.25%	Metal Film	12128060 A
R 168	8250			12123880 A
R 169	-		Not used	-
R 201	1210			12123080 A
R 202	270	2w	Composition	12128130 A
R 203	15	5w	Wirewound	12128140 A
SWITCHES				
S 1-4			Toggle Switch	25100010 A
TRANSFORMERS				
T 1			Power Transformer	20100031 L
REGULATORS				
U 201-202	LM 3407-15	15 V	IC Voltage Reg.	24100520 A



TYPE TSF, TOP VIEW



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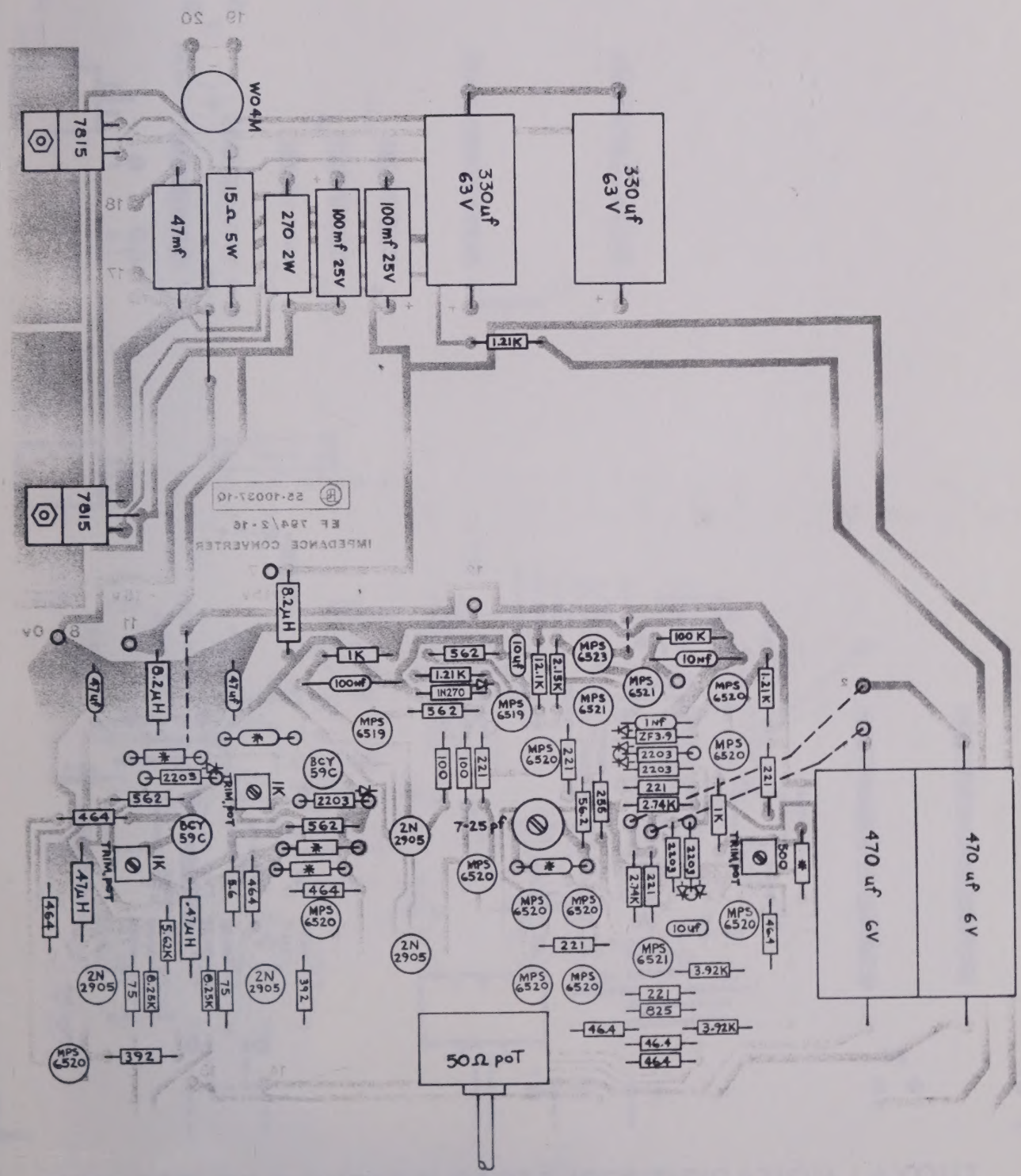
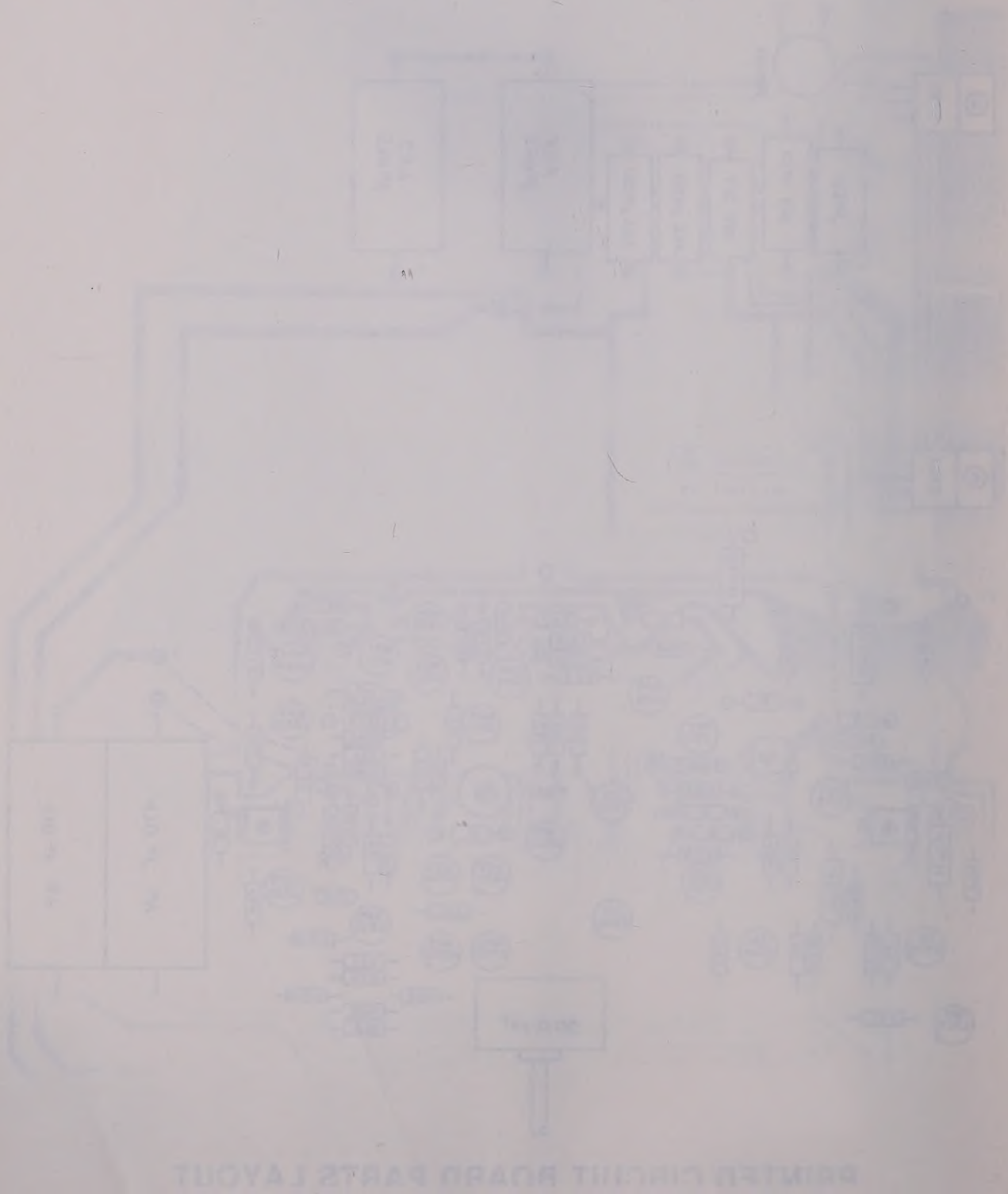
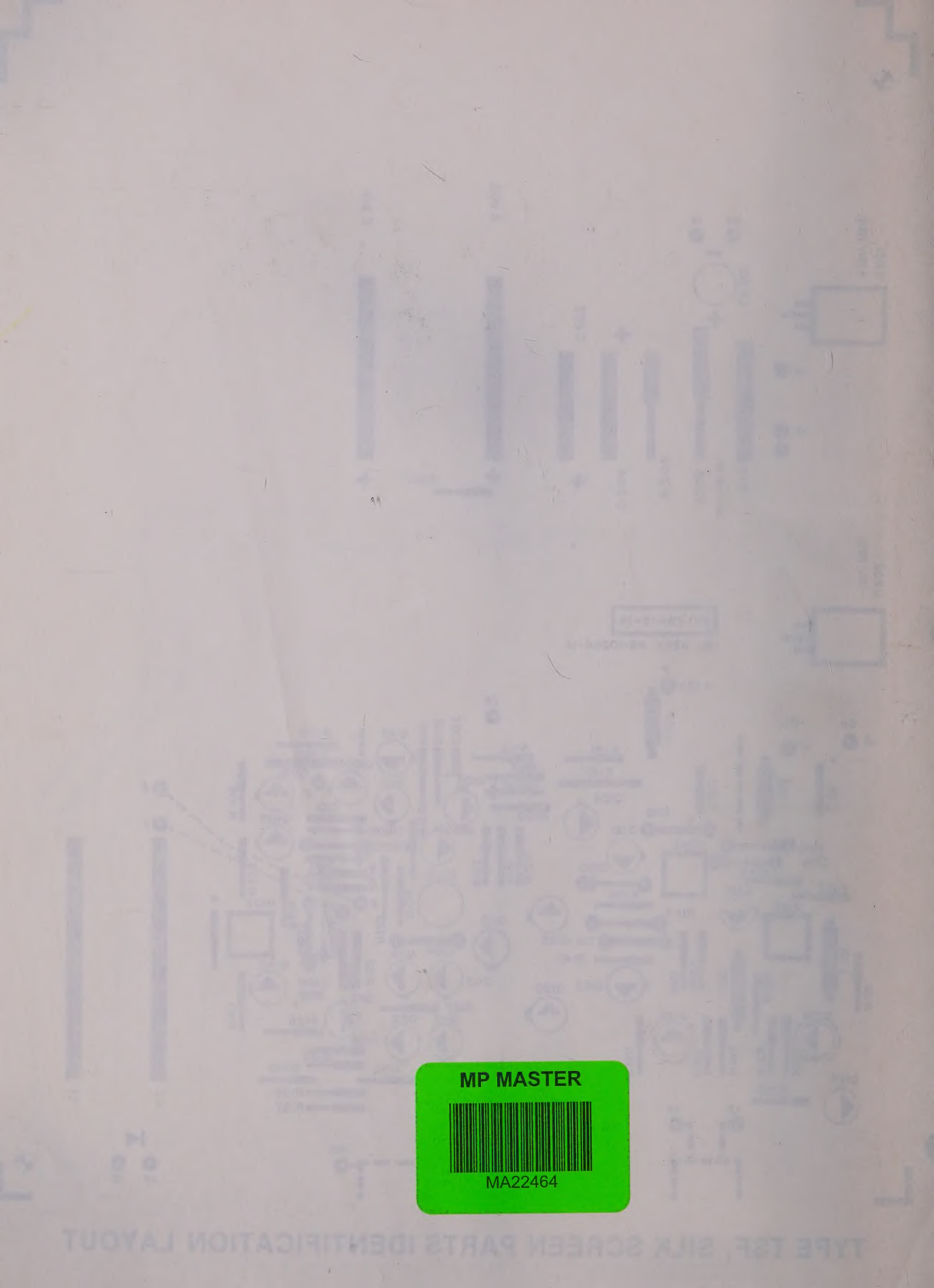


PRINTED CIRCUIT BOARD PARTS LAYOUT



TYPE TSF, SILK SCREEN PARTS IDENTIFICATION LAYOUT



MP MASTER
MA22464